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The comparison of Grime's strategies of plant taxa in Hacı Osman Forest and Bafra Fish Lakes in the central Black Sea region of Turkey

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Abstract: The main aim of this study was to compare Grime's strategies in 91 plant taxa occurring from the eastern to the western part of the central Black Sea region of northern Turkey (Samsun). To do this, 45 sample plots were taken from different community types (from swamp forests to halophytic communities), and the strategies of plant species were compared with each other. Many tree and shrub species present in Hacı Osman Forest, a protected swamp forest, exhibited a purely competitive (C) strategy; some other tree and shrub species exhibited secondary strategies such as competitive/competitive stress-tolerant (C/CS) and competitive/competitive ruderal (C/CR). The ecological features of Hacı Osman Forest and Galeriç Forest are similar, and species of either forest tended to adopt stress-tolerant strategies. Coastal dune species within the study area exhibited transient strategies. Finally, it was evaluated that the CSR classification model can be successfully applied to determine the responses of plant species to changing land use patterns and disturbance factors, even for woody shrub and tree species, although our data were not entirely consistent with Grime's succession theory.

Key words: Grime's strategies, competition, disturbance, stress, plant functional types

1. Introduction

Plant traits are linked to plant function and provide insight into the key processes driving vegetation changes, in order to predict ecosystem response to environmental changes arising from both human-induced and natural factors such as fire, flooding, biological invasions, and climatic changes. Modern plant functional type (PFT) approaches therefore attempt to classify vegetation according to functional features, disregarding traditional taxonomic classification and showing that taxonomically unrelated species exhibit similar ecological responses to environmental changes. It has been stated that both plant species and plant functional types are important controllers of ecosystem processes and functions (Box, 1995; Diaz & Cabido, 1997; Lavorel & Garnier, 2002; Bond et al., 2005; Prévosto et al., 2011; Shi et al., 2012).

The term 'strategy' has been defined as 'a grouping of similar or analogous genetic characteristics that re-occurs widely amongst species or populations and causes them to exhibit similar ecology' (Grime et al., 1988). Grime's 3-strategy model classifies plant species based on adaptive strategies in dealing with 2 groups of external environmental factors, namely stress and disturbance. According to Grime's CSR model, 3 primary strategies, namely competitive (C), stress-tolerant (S), and ruderal (R), and several secondary strategies (CS: competitive stress-tolerant; CR: competitive ruderal; SR: stress-tolerant ruderal; CSR: competitive stress-tolerant ruderal) can be distinguished, which can be displayed in a triangular ordination space (Hodgson et al., 1999). Owing to the importance of interspecific competition, niche diversification, and the coexistence of species in the community, these strategy models have currently become quite popular in plant ecology (Grime, 1977, 1979, 2002; Tilman, 1990, 1994).

Some alternative functional approaches to Grime's CSR theory for classification of plant communities have been developed, such as Tilman's resource-ratio hypothesis (Tilman, 1990) and Ellenberg's indicator values (Ellenberg, 1988). Tilman (1994) criticised Grime's CSR theory because it does not explain competition between below- and above-ground parts of species via partitioning of biomass. However, Grime's theory is considered to be a fundamental functional classification. This classification

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system is an individual-based functional type model and is based on autecological databases for each plant species. Knowledge of the autecology of a particular species is essential for determination of the ecological requirements of that species and provides basic knowledge for relevant authorities such as range managers (Fakhireh et al., 2012). CSR classification can therefore apply to large numbers of plants in situ, thereby allowing the investigation of communities within a functional context (Caccianiga et al., 2006).

It has been stated that plant strategies differ considerably during stages of successional change (Ecke & Rydin, 2000; Caccianiga et al., 2006; Prévosto et al., 2011). Grime (1987) suggested that stress-tolerant species are likely to dominate at the onset of succession, whereas competitive species constitute the climax phase of primary succession; however, the opposite pattern was said to occur during secondary succession.

Although Grime's CSR model is accepted as a confident approach to the classification of plant species according to functional features, there are few studies of the general applicability of this model outside the British Isles (Grime, 1987; Cerabolini et al., 2010). In this study, we aimed (1) to determine the established strategies of some characteristic plant species in diverse community types (swamp forests, meadows, coastal dunes, salt marshes, and lakes) occurring in the central Black Sea region of Turkey; (2) to compare some woody species occurring in protected (Hacı Osman Forest in the eastern part of the study area) and nonprotected (Galeriç Forest in the western part of the study area) swamp forests with respect to CSR strategies, and to evaluate similarities and differences among plant taxa regarding established plant strategies.

2. Materials and methods

2.1. Study area

The study area is situated in the north-eastern part of Turkey, along the Black Sea coast, near the city of Samsun. The study area extends from the eastern to the western part of the central Black Sea region. Mean altitude from sea level (*m. a. s. l.*) ranged from 0 to 20 m. The study area includes different and extreme habitat types, from swamp forests to halophytic communities, and is defined as a unique and endangered alluvial ecosystem of international importance (Kutbay et al., 1998).

The eastern part of the study area has an oceanic-type climate with 885.2 mm mean annual precipitation (P); summer drought is not observed in the area**.** Mean annual temperature is 13.8 °C. Summer rainfall (PE) is 152.2 mm. Mean maximum for the hottest month (M) and mean minimum for the coldest month (m) are 27.7 and 2.1 °C, respectively. Index of xericity ($S = PE/M$) is 5.4. Pluviometric quotient ($Q = 2000P/M + m + 546.4[M - m]$) is 121.3, and the precipitation regime is East Mediterranean (Autumn, Winter, Spring, Summer; Au, Wi, Sp, Su) (Kutbay, 2001; Yalçın et al., 2011). In the eastern part of the study area (41°18′N, 36°55′E), there is an undisturbed swamp forest named Hacı Osman Forest. This forest covers approximately 86 ha and is classified as a unique and endangered world-class alluvial ecosystem. The tree layer is mainly characterised by *Fraxinus angustifolia* Vahl. subsp. *oxycarpa* (M.Bieb. ex Willd.) Franco & Rocha Afonso forests. *Fraxinus excelsior* L., *Pterocarya fraxinifolia* (Poiret) Spach, *Quercus hartwisiana* Steven, and *Alnus glutinosa* (L.) Gaertner subsp. *glutinosa* are the co-dominant tree species; cover values (%) of the tree species ranged from 70 to 80. This area is characterised by hydromorphic alluvial soils (Kutbay, 2000, 2001).

The western part of the study area has a Mediterranean-type climate with 672.4 mm mean annual precipitation (P); summer drought occurs from June to August. Mean annual temperature is 13.5 °C. Summer rainfall (PE) is 105.0 mm. Mean maximum for the hottest month (M) and mean minimum for the coldest month (m) are 30.1 and 2.9 °C, respectively. Index of xericity ($S = PE/M$) is 3.4. Pluviometric quotient (Q) is 85.4 and precipitation regime is East Mediterranean (Au, Wi, Sp, Su) (Yalçın et al., 2011). The western part of the study area is located near the Bafra Fish Lakes (41°42′N, 36°05′E) and different habitat types occur, namely swamp forests, meadows, halophytic communities, and coastal dunes, in contrast to the eastern part, which includes only a swamp forest. A second swamp forest named Galeriç Forest occurs in the western part of the study area, which has similar ecological and edaphic properties to Hacı Osman Forest. However, this forest is subjected to severe disturbance factors, mainly commercial lumber production, and its area has receded from 3564 ha to 3106 ha. The tree layer in this forest is also characterised by *F. angustifolia* subsp. *oxycarpa*, and co-dominant species are similar to those of Hacı Osman Forest. However, Galeriç Forest has been severely disturbed, and cover values (%) of the tree layer ranged from 55 to 65. In addition to Galeriç Forest, coastal dunes, salt marshes, herblands, halophytic communities, and lakes occurred around Bafra Fish Lakes. Coastal dunes were characterised by *Euphorbia paralias* L., *Euphorbia peplis* L., *Pancratium maritimum* L., *Otanthus maritimus* Hoffman & Link, and *Medicago marina* L. Cover values (%) of these species ranged from 20 to 40. Herblands are mainly characterised by *Medicago polymorpha* L. var. *polymorpha* and *Alopecurus myosuroides* Hudson var. *myosuroides*; cover values of these species were 60%. Halophytic communities were characterised by *Salicornia prostrata* L. subsp. *prostrata* (cover value: 60%). Lake communities were characterised by *Phragmites australis* (Cav.) Trin. ex Steudel and *Typha latifolia* L. (cover values were 50% and

55%, respectively). These vegetation types replaced each other around Bafra Fish Lakes, and hydromorphic alluvial and saline soils were the predominant soil types.

This area faces severe environmental threats due to human-induced disturbance. Overgrazing and mowing are the most significant disturbance factors in the study area, especially in herblands. Overgrazing by livestock has resulted in land degradation in the area (Karadeniz et al., 2009).

2.2. Vegetation sampling and ordination of species within CSR space

Forty-five sample plots were selected from homogeneous areas, and 91 plant species were selected from the plots with the highest cover values to determine the predictor variables for Grime's CSR strategies. Species with cover values of less than 10% in these plots were excluded. Calculation of CSR coordinates was performed for the 91 study species, following the method of Hodgson et al. (1999), using the following plant characteristics: canopy height, leaf dry matter content, flowering period, flowering start, leaf dry weight, lateral spread, leaf area, and specific leaf area (Table 1). Plant specimens and phytogeographical regions were determined according to *Flora of Turkey* (Davis et al., 1965–1988; Güner et al., 2000).

Plant height was estimated for each species using a Haglof hypsometer in the field. For specific leaf area (SLA) calculations of each plant species, the largest and fully hydrated leaves of adult individuals of each plant species were used. SLA values (mm^2/mg) of each species were calculated using the following equation:

$$\mathrm{SLA} = \frac{\text{Mean leaf area } (\mathrm{mm}^2)}{\text{Mean leaf dry weight (mg)}}$$

Leaf dry weight (LDW) was then determined following drying for 24 h at 105 °C until a constant weight was reached.

The percentage of the leaf dry matter content of leaves (LDMC) was calculated by the following equation:

$$\mathrm{LDMC}\ (\%) = \frac{\text{Mean dry weight (mg)}}{\text{Mean fresh weight (mg)}} \times 100$$

Table 1. Definition of the predictor variables of the CSR allocation of plant species (Hodgson et al., 1999).

Variable			Definition
Canopy height	Six-point classification	1	1–49 mm
		2	50–99 mm
		3	100–299 mm
		4	300–599 mm
		5	600–999 mm
		6	>999 mm
Dry matter content	Mean of percent dry matter content in the largest, fully hydrated, fully expanded leaves (%)		
Flowering period	Normal duration of flowering period (months)		
Flowering start	Six-point classification	1	First flowering in March or earlier
		2	in April
		3	in May
		4	in June
		5	in July
		6	in August or later, or before leaves in spring
Lateral spread	Six-point classification	1	Plant short-lived
		2	Compactly tufted about a single axis, no thickened rootstock (in non-graminoids)
		3	Compactly tufted ramets appressed to each other at base (in graminoids)
		3	Compactly tufted about a single axis, thickened rootstock present (in non-graminoids)
		4	Shortly creeping, <40 mm between ramets
		5	Creeping, 40–79 mm between ramets
		6	Widely creeping, >79 mm between ramets
Leaf dry weight	Natural logarithm of mean dry weight in the largest, fully hydrated, fully expanded leaves (mg), plus 3		
Specific leaf area	Mean of area/dry weight quotient in the largest, fully hydrated, fully expanded leaves (mm^2/mg)		

Flowering start and flowering period were measured at the individual plant level by weekly phenological observations. The term 'flowering start' indicates when the first flowering bloom was observed for each species and 'flowering period' refers to the duration of flowering. The flowering period is required for nonherb species.

After 7 predictor variables (6 predictor variables for herbs) were established for each species, these variables were entered into spreadsheets and the established strategies were determined by automatic data transformation. The CSR strategy of a species was determined in 5 steps: data assembly, regression, transformation, adjustment, and identification of CSR type. Coordinate values ranged from −2.5 to 2.5: data were translated onto a positive axis with the minimum value set as zero. C, S, and R values were then transformed into percentages for each species prior to plotting (Hodgson et al., 1999).

3. Results and discussion

Of the studied species, 25.27% belonged to the Euro-Siberian phytogeographical region, 2.19% to the Mediterranean phytogeographical region, 1.13% to the East Mediterranean phytogeographical region, and 1.09% to the Hyrcano-Euxine phytogeographical region, while 70.32% of the species were pluriregionals. Almost all plant species in the study area exhibit secondary or transient Grime's strategies (1979), such as C/CR or CR/CSR (Table 2).

It has been suggested that low stress and disturbance allow competitive traits to be exhibited in plant species, and this suggestion was consistent with Grime's contention (Grime et al., 1985). In the present study, many tree and shrub species in Hacı Osman Forest were found to adopt purely C strategies. In fertile and undisturbed environments like Hacı Osman Forest (Kutbay, 2001), plant height is a good index of competitive ability (Lepš, 1999; Willby et al., 2001).

Although Galeriç Forest has similar ecological and edaphic characteristics as Hacı Osman Forest, some common species may use different types of strategy (Table 2). For example, *Ligustrum vulgare* L., *Crataegus monogyna* Jacq., and *Quercus hartwissiana* Steven present C strategies in Hacı Osman Forest, whereas the same species present CS, C/CS, and CS strategies respectively in Galeriç Forest. Canopy trees in Galeriç Forest were subjected to severe disturbance factors, and so subcanopy species adapted to more extreme environmental gradients (e.g., greater light acquisition) and there was a greater number of stress-tolerant species. In such conditions, competitor species may fail to become dominant (Kolb et al., 1990; Bonham et al., 1991; Boulangeat et al., 2011).

It should be emphasised that different ecosystems along the Bafra Fish Lakes, such as coastal dunes, salt marshes, and meadows, are subject to severe disturbance factors. Embryonic dunes are threatened by sand extraction and construction works (Sýkora et al., 2003; Alphan & Yılmaz, 2005; Çakan et al., 2011). This implies the risk of extinction of characteristic coastal species and replacement by alien species. On the other hand, grazing and mowing frequency is very high in the salt marshes and meadows within the study area, severely affecting the natural vegetation.

Kılınç and Karaer (1994) reported that, during the early stages of primary succession, *Euphorbia paralias, E. peplis, Pancratium maritimum*, *Otanthus maritimus*, *Medicago marina*, *Crepis foetida* L. subsp. *rhoeadifolia* (M. Bieb) Celak, *Cakile maritima* Scop., and *Calystegia soldanella* L. were more abundant in the coastal dunes of the western Black Sea region. In the present study, the same species are also dominant in coastal dunes, which represent the early stages of primary succession. Kuiters et al. (2009) also found that competitors (C) were increased, whereas ruderals (R) and stress-tolerators (S) were less common in coastal dune vegetation when succession proceeded gradually, in accordance with Grime's CSR classification. It has also been found that the number of competitors increased significantly, whereas the ruderals declined towards climax state in some European habitats (Prévosto et al., 2011). However, the established strategies of these species were found to be CR/CSR, CR, CR, R/CR, CS, CR, CR, and C/CR, respectively. The results show that transient strategies were widespread during the early stages of succession in the present study. Grime (2002) also pointed out that coastal dunes and inland dunes are composed of unstable sand or shingle, and the effects of wave action and daily inundation prevent the establishment of vascular plants on the lower parts of the coastal line. However, our results are inconsistent with Grime's succession theory because the ruderal (R) strategy is totally absent in the coastal dunes of the study area. Hence, our findings are not entirely supportive of Grime's succession model.

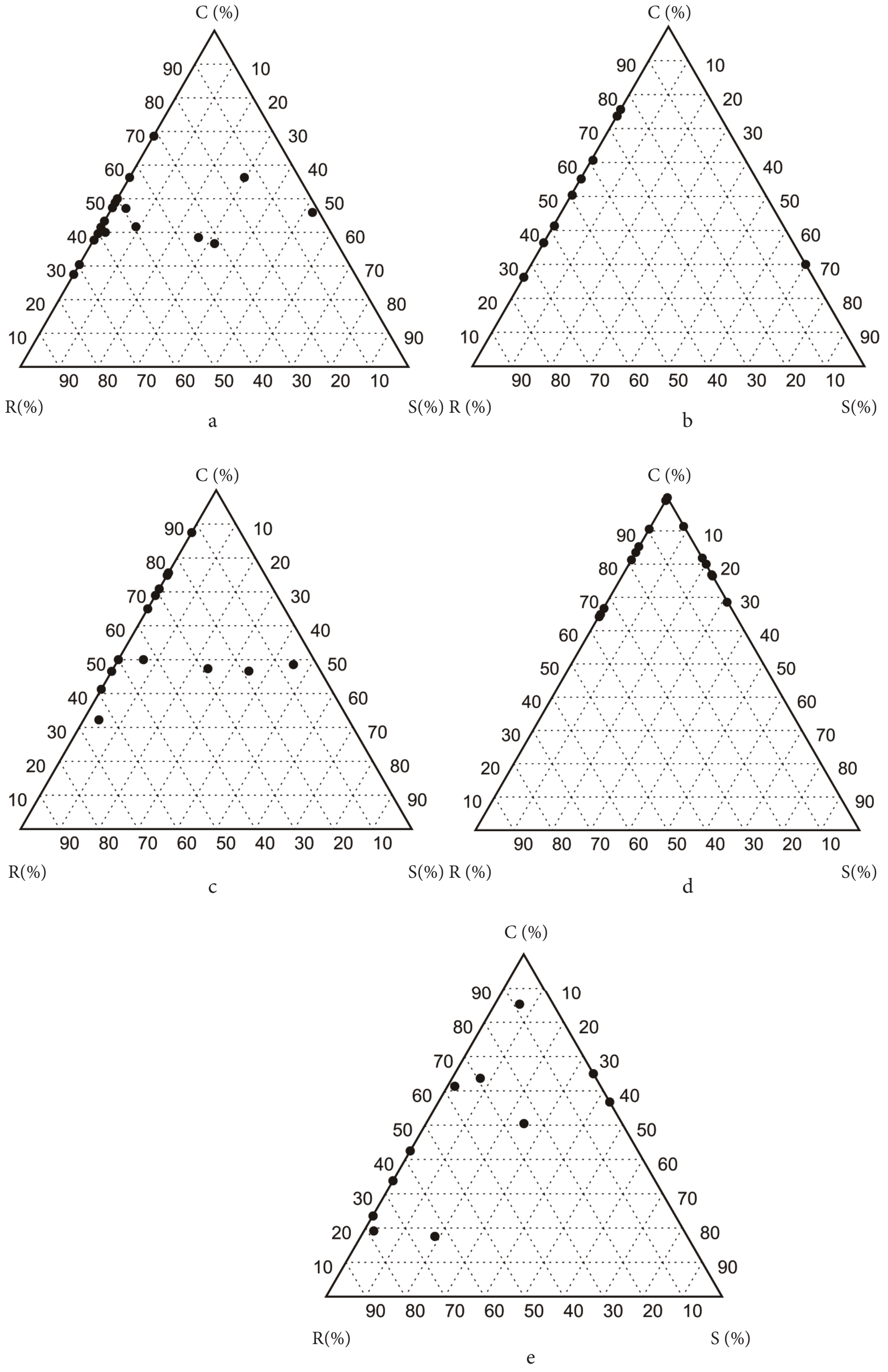
Our data showed that some species exhibit strategies similar to those defined by Grime et al. (1988) in inland areas of Britain. However, some differences were also found. For example, of the coastal dune species, *Salsola kali* L. and *Cakile maritima*. displayed CR strategy, whereas Grime et al. (1998) found that these coastal dune species displayed R strategy. Similarly, a strongly rhizomatous hydrophyte species, *Phragmites australis* (Cav.) Trin. ex Steudel, showed CS strategy in the present study, whereas studies by Grime (1988) and Ecke and Rydin (2000) found that *P. australis* displayed a C type strategy. We must emphasise that a species may change strategies within CSR space due to habitat characteristics, nutrient availability, light conditions, and intensity of disturbance factors. Similar results were also obtained by Hunt et al. (2004) and Çakır et al. (2010). For example, *Acer campestre* L. subsp.

Table 2. Data of predictable variables and CSR strategy types of the species.

Taxa	Hacı Osman Forest	Galeric Forest	Strategy type (Hunt et al., 2004)	Cover (%)	Growth form	Family	Taxa Galeriç Forest	Strategy type	Strategy type (Hunt et al., 2004)	Cover (%)	Growth form	Family
	Strategy type											
Leucojum aestivum	C	C/SC	-	35	Herb	Amaryllidaceae	*Hedera helix*	C	CS	35	Shrub	Araliaceae
Iris pseudacarus	C	C/CS	-	25	Herb	İridaceae	*Cornus sanguinea*	C	CS	20	Shrub	Cornaceae
Ornithogalum sigmoideum	C	C	-	20	Herb	Liliaceae	*Rubus hirtus*	C/CS	-	20	Shrub	Rosaceae
Smilax excelsa	C	C	-	30	Herb	Liliaceae	*Pterocarya fraxinifolia*	C/CS	-	45	Tree	Juglandaceae
Ruscus aculeatus var. *aculeatus*	C/SC	C/SC	-	30	Herb	Liliaceae	*Morus alba*	C/CS	-	15	Tree	Moraceae
Rubus discolor	C	C	-	20	Herb	Rosaceae	**Hacı Osman Forest**					
Cornus mas	C	C	-	25	Shrub	Cornaceae	*Euonymus latifolius*	C	-	20	Shrub	Celastraceae
Hippopheae rhamnoides subsp. *caucasica*	C	C	-	35	Shrub	Eleagnaceae	*Rubus sanctus*	C	-	15	Shrub	Rosaceae
Ligustrum vulgare	C/CS	C/CS	CS	25	Shrub	Oleaceae	*Crataegus monogyna*	C/CS	CS	20	Shrub	Rosaceae
Frangula alnus subsp. *alnus*	C	C	-	30	Shrub	Rhamnaceae	*Acer campestre* subsp. *campestre*	C	CS	40	Tree	Aceraceae
Rosa canina	C/CR	C/CR	CS	20	Shrub	Rosaceae	*Alnus glutinosa* subsp. *glutinosa*	C	R	35	Tree	Betulaceae
Carpinus betulus	C	C	-	35	Tree	Corylaceae	*Malus sylvestris*	C/CS	-	15	Tree	Rosaceae
Carpinus orientalis	C/CS	C/CR	-	35	Tree	Corylaceae	*Populus alba*	C	-	15	Tree	Salıcaceae
Quercus hartwissiana	C/CS	C	-	30	Tree	Fagaceae	*Staphuka pinnata*	C	-	25	Tree	Staphylaceae
Ficus carica subsp. *carica*	C	C	-	15	Tree	Moraceae	**Bafra Fish Lakes**					
Fraxinus angustifolia subsp. *oxycarpa*	C	C	-	80	Tree	Olaceae	*Narcissus tazetta* subsp. *tazetta*	C/CR	-	20	Herb	Amaryllidaceae
Fraxinus excelsior	C	C	C	45	Tree	Oleaceae	*Eryngium maritimum*	C/CR	-	30	Herb	Apiaceae
Prunus spinosa subsp. *dasyphylla*	C	CS	-	15	Tree	Rosaceae	*Cionura erecta*	C/CR	-	35	Herb	Apocynaceae
Pyrus communis	C/CR	C/CR	-	15	Tree	Rosaceae	*Crepis foetida* subsp. *rhoeadifolia*	CR	-	15	Herb	Asteraceae
Salix alba	C/CR	S/SC	-	30	Tree	Salicaceae	*Butomus umbellatus*	CR	-	35	Herb	Butomataceae
Ulmus glabra	C	C	C	30	Tree	Ulmaceae	*Calystegia soldanella*	C/CR	-	25	Herb	Convolvulaceae

Table 2. (Continued).

Taxa	Strategy type	Strategy type (Hunt et al., 2004)	Cover (%)	Growth form	Family	Taxa	Strategy type	Strategy type (Hunt et al. 2004)	Cover (%)	Growth form	Family
Calystegia silvatica	C/CR	C/CR	20	Herb	Convolvulaceae	*Salsola kali*	CR	-	35	Herb	Chenopoiaceae
Schoenoplectus lacustris subsp. *tabernaemontani*	C	-	40	Herb	Cyperaceae	*Carex divisa*	R/CR	-	30	Herb	Cypeaceae
Cyperus fuscus	CR	-	20	Herb	Cyperaceae	*Typha latifolia*	C	C	60	Herb	Cyperaceae
Euphorbia peplis	CR	-	20	Herb	Euphorbiaceae	*Phragmites australis*	CS	C	55	Herb	Cyperaceae
Euphorbia peplus	CR	-	20	Herb	Euphorbiaceae	*Euphorbia hirsuta*	CR/CSR	-	15	Herb	Euphorbiaceae
Erodium cicutarium subsp. *cicutarium*	CR	-	15	Herb	Geraniaceae	*Euphorbia paralias*	CR/CSR	-	30	Herb	Euphorbiaceae
Glaucium flavum	C/CR	-	20	Herb	Papaveraceae	*Euphorbia platyphyllos*	CR/CSR	-	15	Herb	Euphorbiaceae
Hordeum bulbosum	CR	-	20	Herb	Poaceae	*Lotus corniculatus* var. *tenuifolius*	CR	-	15	Herb	Fabaceae
Polygonum salicifolium	C/CR	-	10	Herb	Polygonaceae	*Medicago marina*	CS	-	30	Herb	Fabaceae
Ranunculus trichophyllus	C/CR	R	25	Herb	Ranunculaceae	*Medicago polymorpha* var. *polymorpha*	CS	-	60	Herb	Fabaceae
Linaria pelisseriana	CR	-	20	Herb	Scrophulariaceae	*Sophora alopecuroides* var. *alopecuroides*	CS	-	30	Herb	Fabaceae
Tamarix smyrnensis	C/CR	-	20	Shrub	Tamaricaceae	*Hydrocharis morsus-ranae*	R/CR	-	10	Herb	Hydrocharitaceae
Sparganium erectum	C/CR	C/CR	35	Herb	Typhaceae	*Juncus acutus*	C/CS	-	60	Herb	Juncaceae
Alisma plantago subsp. *aquatica*	CR	R/CR	25	Herb	Alismataceae	*Satureja hortensis* var. *grandiflora*	CR	-	15	Herb	Lamiaceae
Pancratium maritimum	CR	-	40	Herb	Amaryllidaceae	*Mentha aquatica*	R/CR	C/CR	15	Herb	Lamiaceae
Apium graveolens	CR	-	20	Herb	Apiaceae	*Lythrum salicaria*	C/CS	C/CSR	30	Herb	Lythraceae
Daucus carota	CS	-	20	Herb	Apiaceae	*Plantago lanceolata*	CR	-	20	Herb	Plantaginaceae
Aster tripolium	CR	-	25	Herb	Asteraceae	*Plantago coronopus* var. *coronopus*	R	-	35	Herb	Plantaginaceae
Silene dichotoma subsp. *dichotoma*	*CR*	-	15	Herb	Caryophyllaceae	*Alopecurus myosuroides* var. *myosuroides*	R/CR	-	60	Herb	Poaceae
Salicornia prostrata	CR	-	60	Herb	Chenopodiaceae	*Lagurus ovatus*	R/CR	-	20	Herb	Poaceae
Spergularia marina	R/CR	-	35	Herb	Chenopodiaceae	*Bellis perennis*	R/CR	-	15	Herb	Asteraceae
Suaeda prostrata. subsp. *prostrata*	R/CR	-	20	Herb	Chenopodiaceae	*Otanthus maritimus*	R/CR	-	40	Herb	Asteraceae
Scorzonera cana var. *cana*	R/CR	-	15	Herb	Asteraeae	*Samolus valerandi*	CR	S/CSR	20	Herb	Primulaceae
Cakile maritima	CR	-	35	Herb	Brassicaceae	*Artemisia santonicum.*	C/CR	-	40	Herb	Typhaceae
Cardamine tenera	R/CR	-	15	Herb	Brassicaceae	*Urtica dioica* subsp. *dioica*	C/CR	C	15	Herb	Urticaceae
Polygonum maritimum	CR	-	20	Herb	Polygonaceae						



a

b

c

d

e

Figure 1. The frequency of plant strategies in different communities. a- meadow communities; b- lake communities; c- coastal dune communities; d- swamp forests; e- halophytic communities.

campestre exhibits C strategy in the present study, while this species exhibits CS strategy in Europe. Similarly, we found that *Alnus glutinosa* (L.) Gaertner subsp. *glutinosa* exhibits C strategy, whilst Hunt et al. (2004) stated that this species exhibits R strategy in Europe. Therefore, it is very difficult to state that one species demonstrates the same strategy in all habitats.

Salicornia prostrata Pall., *Spergularia marina* L., and *Plantago coronopus* L. var. *coronopus* occurred in salt marshes and exhibited CR, R/CR, and R strategies, respectively. *Salicornia prostrata* was much more abundant than other halophytes in the study area and its dominance is consistent with its competitive ability. Grime (1998) suggested that a certain species may eliminate others due to its competitive ability, especially in harsh environments.

Vegetative growth and reproduction of species distributed in meadows along the Bafra Fish Lakes are restricted by overgrazing. Meadow species in the study area generally exhibited R/CR or CR strategy types. These species are annuals or short-lived perennials, and have a tendency for rapid growth. Competitive species were treated as dominant species by Hodgson et al. (1999) and Grime (1998, 2006). However, some spring geophytes in meadows, for example *Ornithogalum sigmoideum* Freyn & Sint., *Leucojum aestivum* L., and *Narcissus tazetta* L. subsp. *tazetta,* represent C or C/CR strategies, although they are not dominant species in meadows. Some geophytes have a complementary effect on the properties of ecosystems with dominant species and they temporally make a minor contribution to the biomass of herblands (Grime, 2006).

The species that occupied transitional areas from sand plains to herblands, such as *Rubus discolor* Weine & Nees and *Hippophae rhamnoides* L. subsp. *caucasica*, display C strategies. Both species are perennials and are often preferred by invertebrate herbivores due to their relatively palatable leaves. This result supports Grime's (2002) criteria for competitor species. Another widespread species, *Juncus acutus* L., occurs not only in coastal dunes, but also in the salt marshes and meadows of the study area. However, this species was not dominant in any of the habitat types. According to the results of the present study, *J. acutus* used the transient strategy between competitor and competitive stress-tolerant. This is a perennial species and it has a capacity for extensive lateral vegetative spread by means of underground rhizomes or expanding tussocks. Grime (2002) found that British *Juncus* (sedge) species adopted C/CS transient strategy due to their evergreen functional shoots and usually showed lateral spread. Schleicher et al. (2011) also stated that the perennial species required many years to establish a dense clonal network following initial colonisation and were unable to completely exclude plants with other trait expressions in later stages of succession, particularly in stressful habitats.

The presence of ruderals and CR strategists in the more disturbed communities like halophytic, dune, and meadow communities in the study area (Figure 1) confirms that disturbance strongly influences niche segregation; faster-growing ruderals and competitive ruderals necessarily require a local abundance of nutrients and are well-adapted to propagate genes before ephemeral nutrient patches become exhausted, due to their rapid inherent development and completion of the life cycle (Pierce et al., 2007).

Although the validation of the CSR allocation procedure involved a very large proportion of the herbaceous species, there is no theoretical reason why the approach may not be extended to deal with woody species (Hodgson et al., 1999). Although Cerabolini et al. (2010) did not consider woody species within the CSR context, we obtained satisfactory results for shrub and tree species in swamp forest communities. Navas et al. (2010) also found that CSR strategies may be applied to woody species. In this study, the CSR classification model was successfully applied to determine responses of plant species to changing land use and disturbance factors, although this theory was not entirely consistent with our data. We hope that future studies that build on CSR theory could refine the CSR classification into a more generally applicable methodology for the functional types of vegetation processes, and predict responses to global climatic and anthropogenic land use changes of plant species from a wider range of ecosystems.

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